Determination of Extinction, Refraction and Absorption Contrast in Diffraction Enhanced Imaging

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Introduction: The x-ray imaging technique, Diffraction Enhanced Imaging (DEI), has been used to independently visualize the refraction, absorption and extinction properties of an object. The image contrast is produced by thickness, density and/or composition changes of the sample. It was demonstrated that apparent absorption and refraction are not the only available images which can be used for DEI. This can be understood if attention is focused on ultra-small angle scattering. Therefore, the goal is to apply DEI to determine and to analyze refraction, true absorption and extinction images independently using a different algorithm different than the previous approach.

Methods and Materials: The sample was composed of paper and a cylindrical lucite rod. The intent is to have an object, which can be used to characterize the absorption, refraction and extinction. The lucite rod had a diameter of 6 mm and a length of 58 mm. This object has refraction and absorption. Eight paper layers were used. Paper layers were used as an example of material that exhibits high ultra-small angle scattering (extinction) effects. There are three regions in the sample. One region includes just paper, one region includes just lucite rod and the other region includes both paper and cylindrical lucite rod. The overlapping region will have absorption, refraction and extinction properties in the object. The left over area around the sample is air. Paper layers were used as an example of material that exhibits high ultra-small angle scattering (extinction) effects. These layers give a variable thickness of scattering.

Results: Since in DEI, the apparent absorption image has the combined effect of extinction and true absorption an algorithm was developed to decompose the images into their separate individual components. At different analyzer crystal angular positions, images have been taken. The sample had three different major regions and each region shows different characteristics. A fitting procedure was used for each point on the sample to determine the extinction coefficient and refraction angle at that point. The integrated intensity of the analyzed x-rays was used to determine the absorption coefficient on the same point-to-point basis. The resulting coefficients for the representative areas on the sample were compared to determine the success of the algorithm.

Conclusions: The result of the image analysis leads to determine the three major source of information in DEI, the extinction image, which is lost due to extinction process, true absorption image and refraction image, respectively. The results are in good agreement with our model.

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